Geology for part of map modified from Bundtzen and Laird (1982, 1983), and Bundtzen and others (1988). Field mapping for this project primarily by T.K. Bundtzen and M.L. Miller, 1984-1989. Other mappers Base from U.S. Geological Survey, 1956 included: L.M. Angeloni, R.C. Betts, and M.S. Lockwood (1984); G.M. Laird (1984-1985); K.F. Bull, E.J. Moll-Stalcup, and W.W. Patton, Jr. (1985); and B.M. Gamble and R.G. McGimsey (1986). Universal Transverse Mercator projection Manuscript approved for publication June 8, 1993 Edited by Julia Thomas; prepared by Lori Ghequiere CONTOUR INTERVAL 200 FEET NATIONAL GEODETIC VERTICAL DATUM OF 1929 CORRELATION OF MAP UNITS (*See Description of Map Units for specific unit age assignment.) UNCONSOLIDATED DEPOSITS QUATERNARY OUATERNARY AND TERTIARY(?) Unconformity INTRUSIVE AND ULTRAMAFIC ROCKS SEDIMENTARY AND VOLCANIC ROCKS

LOCATION OF FIELD OBSERVATION POINTS (DOTS) AND FOOT TRAVERSES (LINES) IN THE IDITAROD

QUADRANGLE (1984-1989). SHADED 1:63,360-SCALE QUADRANGLES PRIMARILY COVERED PRIOR TO THIS STUDY

TKd TKg* Late Cretaceous CRETACEOUS **CRETACEOUS** Jdr JURASSIC Fault TRIASSIC TO METAMORPHIC ROCKS \ PALEOZOIC AND PROTEROZOIC(?) >EARLY PROTEROZOIC

Mountains and nearby highlands; the oldest of these are thought to be pre-Wisconsin in age and the youngest are judged to be late Wisconsin to early Holocene in age (Bundtzen, 1980; Kline and Bundtzen, 1986). Stream terrace deposits of at least two ages have been identified along the Iditarod River, Crooked Creek, Takotna River, and George River. Although no definitive data are available from the Iditarod quadrangle, stream gravel terraces from unglaciated areas elsewhere in Alaska have vielded Pliocene pollen (Karl and others, 1988), and it is possible that the older terraces in the map area are also late Tertiary in age. Age of unit is primarily Pleistocene and Holocene; some Pliocene deposits may also be present

SEDIMENTARY AND VOLCANIC ROCKS

Basaltic andesite (Miocene) -- Scattered exposures of very fine grained to aphanitic, dark- to medium-gray, locally vesicular, augite basaltic andesite in west-central part of study area. Unit is undeformed and unaltered except for local devitrification. Major-oxide chemistry indicates relatively high TiO2 and low K2O (table 2). Potassiumargon whole-rock ages are 6.9 and 13.0 Ma (table 1) Volcanic rocks of Yetna River area (Tertiary and Late Cretaceous)--Chiefly subaerial lava flows of andesite, dacite, rhyolite, and minor basalt and subordinate welded to nonwelded rhyolitic to andesitic ash-flow tuffs. Outcrops and rubble found mainly in stream bluffs and occasionally on rounded hill tops as tors; columnarjointed andesite is present near VABM Reindeer (T. 28 N., R. 50 W.). Unit thickness roughly estimated at 500 m. Petrographic examination indicates glass is devitrified and alteration by secondary silica and hematite is common. Eight of nine samples yielded K-Ar ages ranging between 54.4 and 68.7 Ma (table 1); the remaining sample yielded an age of 25.5 Ma on plagioclase from a tuff. Unit age is Late Cretaceous and early Tertiary Iditarod Volcanics (Tertiary and Late Cretaceous)-

Dominantly subaerial volcanic rocks consisting of a heterogeneous basal unit (tuff, altered flows, and volcaniclastic rocks) overlain by mafic and intermediate lava flows. Iditarod Volcanics are 500-600 m thick and overlie sedimentary rocks of Kuskokwim Group, but contact relations are ambiguous (Miller and Bundtzen, 1988) and the basal rocks of the Iditarod Volcanics may locally interfinger with the Kuskokwim Group. Age is Late Cretaceous and early Tertiary. In this area, divided into: Andesitic to basaltic subaerial lava flows and mafic volcanic breccia (Tertiary and Late Cretaceous)--Subaerial, locally columnar jointed, aphanitic to porphyritic, olivine-clinopyroxene basaltic andesite, clinopyroxene andesite, and minor dacite; volcanic breccia locally interfingers with flow rocks. Unit is generally resistant forming prominent blocky outcrops and tors near ridgetops. Unit locally contact metamorphosed by stocks of unit TKm as evidenced by secondary, very fine grained, thermal biotite in volcanic groundmass. Potassium-argon ages obtained from four samples (table 1) generally range between 58 Ma and 66 Ma, but one whole-rock sample vielded a 35.1-Ma minimum age. Unit is roughly 150 to 250 m thick and contact with underlying unit Kit may be disconformable. Age is latest Late Cretaceous and early

Tuff, volcanic breccia, altered andesitic to dacitic flows, and volcaniclastic sandstone (Late Cretaceous)--Heterogeneous assemblage characterized by tuff (lithic, crystal, and water-laid) and altered intermediate lava flows; locally includes volcanic breccia, volcaniclastic sandstone, and lahar deposits. Alteration by chlorite and calcite is common. Total unit thickness estimated to be around 350 m. Five K-Ar ages (table 1) range from 76.7 Ma to 70.3 Ma, but the two youngest are minimum ages. Unit may be correlative with unit Kka

Kuskokwim Group (Late Cretaceous; Campanian to Cenomanian) -- In map area, the Kuskokwim Group consists predominantly of sedimentary rocks but also has minor, interbedded volcanic tuff and flow rocks primarily in upper part of section. The sedimentary rocks represent turbidite fan, foreslope, shallow-marine, and shelf facies deposited into a Late Cretaceous basin. Oldest diagnostic fossils found in map area are indicative of Turonian age (table 4), but correlative rocks just south in the Sleetmute quadrangle have yielded bivalve fossils of Cenomanian age (Cady and others, 1955). An upper age of Campanian for the Kuskokwim Group in the map area is defined by one 77-Ma K-Ar age on biotite from an andesite tuff that appears to be interbedded with sedimentary rocks (Kka) in the upper part of the Kuskokwim Group. Outside the study area, the Kuskokwim Group has yielded fossils no younger than early Santonian (Box and Elder, 1992). The Kuskokwim Group is estimated to average 2,200 m in thickness northeast of the Iditarod-Nixon Fork Fault, but may be as much as 5,000 m thick southeast of the fault. In this area, divided into: Quartzose sandstone and siltstone (Late Cretaceous; Campanian to Turonian?)--Quartzose sublithic sandstone, conglomerate, siltstone, and siliceous shale representing shallow-marine and locally non-marine facies. Finer-grained layers locally contain abundant coaly leaf and stem debris; thin coal seams are present at

a few localities. Coquina layers composed of brackish to fresh water bivalves are locally interbedded with sandstone and siltstone. Unit locally contact metamorphosed by stocks of unit TKm resulting in hard, ringing hornfels that contains secondary, very fine grained white mica + biotite. Unit is estimated to be 600 m thick and basal part interfingers with deeper water facies rocks of unit Kks. One dicotyledon leaf fossil (table 4) gives a probable Turonian to Paleocene age but may be as old as latest Cenomanian. Interbedded andesite tuff (Kka) in upper part of section yielded K-Ar age of 77 Ma. Lower age limit of unit is speculated to be Turonian based on interfingering with unit Kks. Upper age limit at least as young as Campanian but not younger than Paleocene Sandstone, siltstone, shale, and conglomerate (Late Cretaceous; Campanian? to Cenomanian)--Thick assemblage of fine- to coarse-grained lithic sandstone, micaceous siltstone, shale, and minor chert-pebble conglomerate that forms the major part of the Kuskokwim Group in the map area. Structures and compositions indicate that unit Kks was primarily deposited by turbidity currents. Sandstones are lithic rich: nearly all contain metamorphic lithic fragments, but plutonic rock, sandstone, chert, limestone, and/or volcanic rock fragments are abundant locally. Quartz clasts are ubiquitous, clasts of plagioclase are very common, but potassium felspar clasts are extremely rare. Finer-grained layers of unit locally contain coaly leaf and stem fragments. Unit locally contact metamorphosed by stocks of unit TKm resulting in hard, ringing hornfels that contains secondary, very fine grained white mica, biotite, and in a few localities, amphibole. Total thickness of unit is poorly known but may be as much as 5,000 m. Seven localities yielded pelecypods indicative of Turonian or probable Turonian age (table 4). However, correlative rocks just south in the Sleetmute quadrangle have yielded

Cenomanian Inoceramus dunveganensis McLearn (Cady

and others, 1955). Upper age limit is not clearly defined

but must be older than the youngest part of unit Kkq,

which generally overlies unit Kks Volcanic tuff and agglomerate (Late Cretaceous)-Heterogeneous assemblage of tuff, agglomerate, cherty tuff, and locally minor sandstone that crops out in isolated areas. Lithologically and petrographically identical to unit Kit; the two units are distinguished only by their associated rocks. Unit Kkt is apparently interbedded with sedimentary rocks (Kks) of Kuskokwim Group, whereas unit Kit is spatially associated with massive flow rocks of unit TKil but could either overlie, or locally interfinger with, the Kuskokwim Group. Near Moore Creek, unit Kkt is at least 50 m thick. Two K-Ar whole-rock ages (69.4 Ma and minimum of 71.3 Ma, see table 1) were obtained from the unit, but they are questionable due to alteration effects. Unit assigned a Late Cretaceous age based or apparent interbedded relation with unit Kks Altered andesite flows, tuffs, and sills(?) (Late Cretaceous; Campanian) -- Unit crops out in the Mosquite Mountain area (southwestern part of the quadrangle) and consists of 1- to 5-m-thick layers of intermediate igneous rocks apparently interbedded with unit Kkq. Unit originally field interpreted as sills due to low-grade thermal metamorphism of enclosing rocks. Petrographic examination revealed instead that it consists chiefly of altered flows and tuffs, but sills may also be present. The flows and tuffs are andesitic in composition and have 15-30 percent phenocrysts of plagioclase, oxidized amphibole clinopyroxene, magnetite, and local biotite in a groundmass of felted plagioclase laths, opaque oxides, and accessory apatite. Plagioclase phenocrysts strongly aligned in some flows. Tuffs characterized by broken crystals and abundant andesite lithic fragments.

Secondary calcite, white mica, and chlorite are present in some samples. Unit age 77 Ma from biotite in andesite tuff (table 1) Volcanic flow(s) and tuff (Late Cretaceous) -- Hornblende clinopyroxene andesitic volcanic flow(s) and chlorite-, calcite-altered tuff. Unit poorly exposed and found only in one area (T. 27 N., R. 42 W.); estimated to be no more than 20 m thick. Unit Kkv is lithologically similar to unit Kkt, but is mapped separately based on presence within it of distinctive brown hornblende phenocrysts. Assigned a Late Cretaceous age based on apparent interbedded relation with unit Kks grained to very fine grained sandstone, tuffaceous

Sandstone and siltstone (Early Cretaceous)--Mediumsandstone, and siltstone exposed only as colluvial chips in western part of map area. Petrographic examination of medium-grained varieties indicates 4-9 percent detrital potassium feldspar in contrast with sandstones of Kuskokwim Group, which are nearly devoid of potassium feldspar clasts. Early Cretaceous age assignment based on Hauterivian to Barremian palynomorphs in one sample age assignment is supported by our faunal collections that yielded Late Triassic (or possibly Jurassic) radiolarians, and a fossiliferous grainstone containing conodonts and crinoidal hash that is no older than mid-Mississippian (table 4). Unit is correlative with the Innoko terrane of Jones and others (1987) and Patton and others (1989b)

INTRUSIVE AND ULTRAMAFIC ROCKS

Porphyritic granodiorite plug (early Tertiary)--Unit consists

of one exposure in T. 28 N., R. 46 W. Small granodiorite

body containing abundant phenocrysts of hornblende and albitic plagioclase in finer-grained, phaneritic groundmass. Hornblende slightly altered to chlorite and minor actinolite. Potassium-argon data on amphibole separate yielded a 52.8-Ma age (table 1) Hypabyssal granite porphyry dikes, sills, and plugs (Tertiary and Late Cretaceous) -- Porphyritic to fine grained phaneritic dikes, sills, and plugs of granitic composition. Phenocrysts of biotite + quartz + plagioclase + sanidine + white mica + trace garnet compose as much as 5 percent of most dikes and 20 percent of most plugs; sericitic alteration common in groundmass. Biotite generally composes less than 5 percent of the samples, so rocks could be classified as alaskite. Unit weathers a distinctive tannish or reddish-brown color and doesn't support vegetation as well as the enclosing sedimentary rocks of Kuskokwim Group. Twenty of twenty-one samples analyzed for major-oxide chemistry are peraluminous (normative corundum 1.0-13.4 percent

table 2). Potassium-argon data on 22 samples (table 1)

indicate a bimodal distribution of ages ranging from 71.5

to 69.1 Ma and 65.7 to 63.5 Ma (one minimum age of 67.0

Ma lies between the two populations). Some mapped exposures show both ages; thus, all hypabyssal granite porphyry rocks are mapped here as a single unit. Age is Late Cretaceous and early Tertiary Pilotaxitic dacite-andesite plugs (Tertiary and Late Cretaceous)--Three small bodies of subvolcanic dacite to andesite are exposed in the east-central part of the quadrangle. Unit is moderately resistant and morphology of exposures suggests they are hypabyssal intrusive bodies rather than volcanic flows, but they have a distinctive pilotaxitic (flow-oriented) texture to the finegrained groundmass. Sparse phenocrysts consist of granophyric plagioclase and rare pyroxene. All samples have very fine grained biotite in the groundmass that looks secondary, therefore unit is thought to be thermally altered. No K-Ar data are available, but unit is assumed to have same age range as lithologically similar intrusive

units in the area. Age is Late Cretaceous and early

Monzonite, quartz monzonite, syenite, granodiorite, granite, and minor lamprophyre (Tertiary and Late Cretaceous)--Small stocks and plutons of fine- to coarsegrained, phaneritic to hypidiomorphic, clinopyroxenebiotite + olivine monzonite, hornblende-clinopyroxenebiotite quartz monzonite, biotite svenite, biotitehornblende granodiorite, biotite granite, and rare Chicken Mountain area where it occurs as highly altered dikes (Bull, 1988), and small pods (biotite-plagioclaseaugite-olivine kersantite). Composite intrusive rocks are in part overlain by, and in part intrude coeval volcanic rocks (Iditarod Volcanics). Hypabyssal textures common near contacts of volcanic rocks and plutonic rocks. Extensive tourmaline alteration present in cupola regions of plutons in Beaver Mountains, at Granite Mountain, and near VABM Tatalina (T. 31 N., R. 36 W.); minor secondary tourmaline is locally present in many of the remaining plutons. Locally grussification and weathering occur to depths of 100 m, but usually the plutonic masses are relatively fresh and resistant, forming the highest uplands in the quadrangle. Potassium-argon data on 20 samples (table 1) indicate a bimodal distribution of ages ranging from 73.2 to 68.3 Ma and 63.4 to 59.4 Ma. Plutonic bodies at Swinging Dome, Granite Mountain, and VABM Tatalina show only the younger group of ages; most other plutons (including the known auriferous ones) are of the older age group. All composite plutons are mapped here

as a single unit because of their lithologic similarity; age is Late Cretaceous and early Tertiary Altered intermediate to mafic dikes (Tertiary and Late Cretaceous)--Porphyritic biotite-clinopyroxene-plagioclase ± olivine dikes, which are partly to extensively altered to chlorite-calcite-silica assemblages. Original compositions were probably intermediate to mafic. Dikes generally are less than 1 m thick, discontinuous, and usually cannot be traced for more than 10 m. Presence of dike is indicated by "x" on the map for visual emphasis, but extent of actual exposures is exaggerated. Samples that yield reliable major-oxide and K-Ar data are extremely difficult to obtain due to ubiquitous alteration. One biotite separate yielded a 71.2-Ma age. Unit assigned same age range as other intrusive rocks in the quadrangle; some dikes may have been feeders for volcanism. Age is Late Cretaceous and

Alkali granite (Tertiary and Cretaceous)--Poorly exposed, medium-grained, granophyric alkali granite found as discontinuous rubble cropping out under heavily vegetated cover in the western part of the map area. All rocks of the unit are light colored (color index <7 percent), but the mafic minerals vary locally. In the southwestern part of the quadrangle (T. 24 N., R. 53 W. and T. 25 N., R. 52 W.) mafic minerals consist of alkali amphibol pyroxene, and biotite, but exposures farther north have biotite (chloritized) only. Unit age assignment is somewhat uncertain. One K-Ar age determination of 62.9 Ma (table 1) was obtained from an amphibole separate on a correlative alkali-amphibole alkali granite in the Fox Hills (about 7 km to the west in the Holy Cross quadrangle). Another age of 140 Ma (table 1) was obtained on a biotite separate from biotite alkali granite in the western part of the quadrangle (T. 29 N., R. 51 W.); however, the K₂O content of this separate was low for biotite, casting some doubt on the validity of this age. It is possible that the more northern biotite alkali granite is indeed older than the alkali-amphibole alkali granite found in the southwestern part of the map area, but we cannot resolve this problem with the available data. We assign this unit a Cretaceous and early Tertiary age Dishna River mafic and ultramafic rocks (Jurassic)-Assemblage of poorly exposed mafic and ultramafic rocks in north-central part of quadrangle. Mafic and ultramafic rocks are probably ophiolitic in origin (Miller, 1990) but now occur as isolated, fault-bounded blocks that lie along the Dishna River Fault Zone. Where observed, the fault contact is a high-angle shear zone that places mafic and ultramafic rocks against sedimentary rocks of Kuskokwim Group. Mafic rocks include two-pyroxene gabbronorite, clinopyroxene + hornblende gabbro, hornblende gabbro, and diabase. Original igneous textures are well preserved in most specimens, but secondary mineral assemblages of actinolite + chlorite + epidote + albitic plagioclase + sphene + quartz suggest the mafic rocks have undergone

low-pressure hydrothermal metamorphism (Miller, 1990). Ultramafic rocks include harzburgite, minor dunite, and rare pyroxenite, all partially to completely serpentinized. Potassium-argon data from this unit (table 1) are of limited value. One sample yielded an age of approximately 225 Ma (Triassic) on hornblende but may be anomalously old due to excess argon retention. The other sample vielded a 92-Ma age but probably represents partial thermal resetting by Late Cretaceous plutonism. Unit assigned a Jurassic age based on correlation with lithologically similar mafic and ultramafic complexes that lie north of the map area (the Tozitna-Innoko belt described by Patton and others, 1989a)

METAMORPHIC ROCKS

Greenschist, pelitic schist, and metagranite (Paleozoic assemblage of greenschist facies metamorphic rocks including mafic meta-igneous rocks, subordinate metasedimentary rocks (pelitic schist, phyllite, calcareous schist, and quartzite), and minor granitic orthogneiss. Mafic schists commonly exhibit secondary mineral assemblages of epidote-chlorite-hornblende/actinolitealbitic plagioclase-quartz + biotite + sphene, indicative of middle greenschist facies, but assemblages characteristic of lower and upper greenschist facies also occur (Angeloni and Miller, 1985). Stratigraphic succession within unit is unknown; contact with surrounding units is everywhere concealed but is interpreted as a fault contact. A biotite separate from granitic orthogneiss yielded a K-Ar date of 108 Ma (table 1), probably a post-metamorphic cooling age. Unit is correlative with rocks of the Ruby terrane as outlined by Jones and others (1987) and Patton and others (1989b), and is therefore assigned the same age. No data on protolith age are available from the map area, but early and middle Paleozoic fossils have been collected from probable correlative rocks to the north (Patton and others, 1989b). While no Proterozoic ages have been reported from rocks of the Ruby terrane, they do occur in ithologically similar assemblages in the southern Brooks Range (Dillon and others, 1980; Mayfield and others, 1983; Patton and others, 1989b). The possibility of a Proterozoic component to the Ruby terrane is further supported by the Sr and Nd isotopic data of Arth and others (1989), which require a Proterozoic source for the Melozitna pluton, a Cretaceous granite that intrudes the Ruby terrane. Unit assigned a Proterozoic(?) and Paleozoic age based on correlation with rocks of the Ruby terrane

Idono Complex (Early Proterozoic)--Foliated metaplutonic rocks, lesser amphibolite, and minor metasedimentary rocks. Outcrop exposure is limited to a dozen localities; frost-riven rubble is sparse but widespread. The compositionally diverse metaplutonic rocks consist primarily of biotite + muscovite granitic orthogneiss but also include orthogneisses of tonalite, granodiorite, quartz diorite, and quartz monzonite, minor metagabbro, and rare hornblendite. Texturally, metaplutonic rocks range from slightly foliated varieties to blastomylonitic augen gneiss. Amphibolite varies little in composition and consists of moderately foliated to well-foliated epidotebiotite-hornblende-intermediate plagioclase + garnet + sphene. The well-foliated, semipelitic metasedimentary rocks include muscovite-biotite-feldspar-quartz ± garnet ± epidote schists. Metamorphic grade of the Idono Complex is amphibolite facies. The Idono Complex is faulted to the east-southeast against unit & Mc, and to the northwest is overlain by subaerial volcanic rocks (TKy) of the Yetna volcanic field. The Idono Complex is assigned a protolith age of 2.06 Ga based on U-Pb zircon and Nd isotopic data (Miller and others, 1991). Potassium-argon ages (table 1) range from approximately 120 Ma to approximately 1,230 Ma and indicate Precambrian, Jurassic, and Early Cretaceous metamorphic events affecting these rocks (see Miller and others, 1991 for more detailed discussion)

Contact--Approximately located

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where concealed; queried where uncertain. Arrows indicate relative movement Thrust fault--Approximately located; queried where uncertain. Sawteeth on upper plate _____ Lineament--Air photo interpretation; queried where uncertain Folds--Showing trace of axial surface and direction of plunge, where known F₂ fold--See accompanying pamphlet Strike and dip of beds or flows--Ball indicates top known Strike and dip of inclined foliation

Potassium-argon sample locality--Numbers refer to table 1

Chemistry sample locality--Major oxides and trace elements:

numbers refer to tables 2 and 3

Fossil sample locality--Numbers refer to table 4

Paleocurrent--Azimuth shown; numbers refer to table 5

Archaeologic sample locality--Numbers refer to table 6

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